

HandGineering

Students design and create prosthetic hands using common classroom materials, then test their designs to find areas for improvement. A student sheet guides students through the design, testing, and revision cycle while highlighting the importance of failure and iteration in the engineering process.

Learning Objectives

- When designing a solution, user needs must be considered.
- In engineering, failure is a critical part of the process and not something to be avoided.
- Engineering requires iterating repeatedly until a workable solution is found.

Class Time

90-180 minutes (the more students iterate, the better!)

Materials

- An internet-capable device per student or student group
- HandGineering student sheets, print or use fillable PDF for a digital option
- A “doodle space” such as blank paper, mini-whiteboards, or digital drawing program
- Inexpensive materials to build a prosthetic hand. Suggestions:

rubber bands	paper
fishing line	aluminum foil
straws or drink stirrers	paper plates
yarn, string, or twine	cardboard
penne or elbow pasta	card stock
pipe cleaners	felt
popsicle sticks	foam
lab gloves	rulers
paper clips	scissors
brads	tape (masking, duct, mailing)
beads	hot glue gun/sticks

Note from the developers

One “constraint” we had in creating this activity was keeping it low cost. It’s completely possible to build a hand out of just paper and masking tape. On the flip side, feel free to clean out your cabinets! Either way, we hope this activity encourages creative thinking for students.

Background Information

Below are some resources for you to learn a bit more about prosthetics and the anatomy of the hand. Feel free to adapt for use with your students.

A short history of prosthetics <https://synergypo.com/blog/a-short-history-of-prosthetics/>

Hand anatomy in brief <https://www.ncbi.nlm.nih.gov/books/NBK279362/>

To inform the design process, you may wish to have students complete the following activities before beginning. Both are found at: (<https://teach.genetics.utah.edu/content/bioengineering/>)

Living with Limb Loss

Students apply reading comprehension skills to tease out what people with limb loss really need from an engineered solution. Can be done individually, in small groups, or as a jigsaw.

Manipulations!

Students learn the elements and functions of hand anatomy systems (bones, muscles, tendons and nerves) through a web-based mini-game in which they practice coordinating the movements of a simulated robotic hand. *Use this as a resource throughout the HandGineering activity.*

HandGineering

The HandGineering Student Sheet guides students through the design, building, and testing phases to build a prosthetic hand.

- Discussion – How is designing an engineering project different from doing a science experiment? How is it similar?
- Briefly discuss the engineering cycle.
- Divide the class into groups of 2-4 students for the project.

Step 1: Design

Page 2 of the Student Sheets will guide this step. Before beginning, share the following with your students:

- Constraints, in terms of materials and time. Set time limits on each section (design and build).
- The criteria (if you're providing), or background resources (like *Living with Limb Loss*) if the students will determine criteria on their own.
 - NOTE: The hand will have to pass a gesture and grasping test at the minimum.
- Decide if each group will work on unique user needs, or if you'll work on 1-2 needs as a class.
- For unique needs, consider chatting with groups after completing questions 1 and 2, to ensure projects are workable.

- As a class, have a group discussion and steer them toward 1 or 2 that you think are appropriate.

Notes:

There is a basic outline of a hand on the last page of this document if you would like to print that out for students to use for brainstorming or designing their prototype.

Students may need help here narrowing down ideas that also fit into the criteria and constraints.

Encourage students to be very detailed in their drawings and to include measurements.

Work with students to facilitate materials needs.

Step 2: Create

Move on to pages 3-4 of the student sheets.

Notes:

You may wish to look over student work from Part 1 before beginning.

Build phase:

- Remind students of time constraints.
- Encourage them to divide tasks if they can in order to maximize their time.

Testing:

- Feel free to have students design their own tests. Instruct them to skip the printed instructions and data table and write out their own. You may wish to spend some time discussing what the best practices are for conducting rigorous tests.
- Ensure students know how to fill out the data tables, calculate averages, and graph the results.
- Consider encouraging students to film the attempts so that they can go back later during the iteration phase to see what went wrong.
- If groups are able to easily do the grasping tests, suggest adding extra force (someone pulls on the object).
- Have all students stop at the end of Step 2 (page 4). Groups that finish early can explore famous “engineering design fails” such as: the sinking of the Titanic, the Tacoma Narrows Bridge collapse, hoverboards, or the Space Shuttle Challenger disaster.

Step 3 - Iterate

Spend as much time as you can in this part. The longer your students spend iterating, the more satisfying this project will be for them and the better they will grasp what engineering is like.

- **What does it mean to iterate?** Hopefully they have gathered enough from the activity to answer this, but if you think they can't come up with anything, feel free to include a definition for them.
- **Analyze your prototype.** Give your students some thoughtful time to reflect and brainstorm some things they can improve. Next, have the students provide peer feedback on their targeted improvements in pairs or small groups. Really focus their work on improving their existing design as opposed to scrapping it and starting over.

Students may want to continue to address gestures or grasping tests, or they may have something totally different to try. One suggestion is to add a thumb that rotates like ours does.

- Let them finish the cycle of drawing, building, and testing the new prototype at least once. They may edit the original drawings and prototypes in this step or start fresh. Set up checkpoints or time limits as desired. Feel free to use the outline we have provided or create your own.
- Analyze the improved prototype. Repeat testing improvements as many times as you'd like.
- **Share.** At any point (or at multiple points) in the process, you could have groups share their work with the class. One strategy for this is a Gallery Walk.

Supplemental Materials

This resource shares information about the Luke Arm prosthetic. To avoid discouraging students or building up false expectations, wait to share it until after they have done their projects.

- <https://spectrum.ieee.org/dean-kamen-luke-arm-prosthesis-receives-fda-approval#toggle-gdpr>

Here are some incredible teen inventors, along with that they invented. Many have TED talks or YouTube videos that might inspire your students.

- Jack Andraka: improved pancreatic cancer test
- Gitanjali Rao: device to detect lead in drinking water
- Deepika Kurup: easier, cheaper method to remove toxins from drinking water
- William Kamkwamba: improvised electrical generator using windmill in Malawi
- Austen Veseliza: digital display glove to aid people with speech impairment
- Cristian Arcega, Lorenzo Santillan, Oscar Vasquez, Luis Aranda: underwater robot
- Heman Bekele: fighting skin cancer with soap